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Status of the Canada Warbler (*Cardellina canadensis*) in Alberta

Alberta Wildlife Status Report No. 70

Alberta Conservation Association

Alberta Government

Status of the Canada Warbler (*Cardellina canadensis*) in Alberta

Prepared for:
Alberta Environment and Sustainable Resource Development (ESRD)
Alberta Conservation Association (ACA)

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PREFACE

Every five years, Alberta Environment and Sustainable Resource Development reviews the general status of wildlife species in Alberta. These overviews, which have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*), 2000 (*The General Status of Alberta Wild Species 2000*), 2005 (*The General Status of Alberta Wild Species 2005*), and 2010 (*The General Status of Alberta Wild Species 2010*), assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A key objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are *At Risk* or *May Be At Risk* in the province, that are of uncertain status (*Undetermined*), or that are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by Alberta Conservation Association and Alberta Environment and Sustainable Resource Development. They are intended to provide detailed and up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

The Canada warbler (*Cardellina canadensis*) was listed as *Threatened* in Canada in 2008 because of large and long-term declines in population size, and because a significant portion of the global population occurs in Canada. It was subsequently appended to Schedule 1 of the *Species at Risk Act* in 2010 as a *Threatened* species. The cause of the decline is not known, but loss and degradation of habitat on the breeding and wintering grounds is suspected. In Alberta, the general status of the Canada warbler has been *Sensitive* since 1996. This designation reflects its low numbers in the province, a long-term decline in population size, and its vulnerability to loss of old-growth deciduous forest habitat.

The Canada warbler is a medium-sized, insectivorous neotropical migrant songbird that breeds in the northern forests of North America and winters in northern South America. It is generally uncommon across its range but can be locally abundant in suitable habitat. In Alberta, it is most commonly associated with stands of old-growth deciduous forest near incised streams in the Boreal Forest and Foothills natural regions. Approximately 11% of the global breeding population of the Canada warbler and 18% of its global area of occupancy is in Alberta. Based on the Breeding Bird Survey, the Alberta population has declined steadily at 3.74% per year since 1975, which is consistent with trends across their North American breeding range. During the most recent ten-year period alone, the Alberta population has declined by 4.74% per year. There is no evidence to suggest the declining provincial trend will not continue in coming years.

Habitat conversion that results in loss of old-growth deciduous forest and forested riparian areas at the local scale, and loss of deciduous forest at the landscape scale are likely the ultimate limiting factors for the Canada warbler in Alberta. Current forestry practices that preferentially target mature forest stands threaten to eliminate older age classes of forest from the Alberta landscape, except for remnant fragments in harvested stands and protected areas. Management practices aimed at conserving old-growth deciduous forest are likely needed to ensure the persistence of suitable breeding habitat for the Canada warbler. Future research that identifies habitat features important for survival and reproduction of the Canada warbler are needed to prioritize areas of old-growth forest for conservation.

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We especially thank Diana Stralberg (Boreal Avian Modelling Project, University of Alberta) for providing population and range estimates, and Richard Krikun and Tyler Flockhart (Lesser Slave Lake Bird Observatory) for providing information on band recoveries, habitat use, and nest associations.

The Boreal Avian Modelling Project (BAM), from which many of the data and models in this report were taken, thanks the BAM funders, data partners, and Technical Committee members. Please visit the BAM website to see full list of data contributors and funders (http://www.borealbirds.ca/). We also thank the support and wise counsel of the BAM Technical Committee: P. Blancher, M. Darveau, J.-L. DesGranges, A. Desrochers, A. de Vries, P. Drapeau, C. Francis, C. Handel, K. Hobson, C. Machtans, J. Morissette, R. Rempel, S. Slattery, P. Taylor, S. Van Wilgenburg, L. Venier, P. Vernier, and M.-A. Villard.

We acknowledge the hundreds of skilled volunteers in Canada who have participated in the Breeding Bird Survey (BBS) over the years, and those who have served as provincial or territorial coordinators for the BBS.

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INTRODUCTION

Canada warblers are a medium-sized, neotropical migrant songbird (Reitsma et al. 2010). Their breeding range spans the boreal forest of North America from the Yukon to Nova Scotia, extending southward in the east into the hardwood forests of New England and at higher elevations along the Appalachian Mountains to northern Georgia and Tennessee. Their winter range is primarily in northern South America on the east slopes of the Andes Mountains from Venezuela to Peru (Reitsma et al. 2010).

Canada warblers are generally uncommon across their range, but they can be locally abundant in suitable habitat. Habitat associations vary by region. In the western portion of their range they are associated with stands of old-growth deciduous forest that have a dense shrub understory and are often near incised streams in valleys with steep banks. Canada warblers also have been recorded in low numbers in stands of regenerating forest that have a dense shrub layer and patches of live residual trees. In the eastern portion of their range they are associated with mixedwood swampland forests and early successional forests created by harvest or natural disturbance.

Canada warblers have been the focus of few directed studies, particularly in the western portion of their range. Numbers of individuals detected on the breeding grounds have declined steadily since broad-scale breeding bird surveys began in the mid-1960s (Panjabi et al. 2012). The decline is believed to be range-wide, but limited data in the west have hampered accurate assessment in this region. Reasons for the decline are unknown, but loss of suitable habitat on both the breeding and wintering grounds is suspected. Declining numbers coupled with the majority of the breeding population occurring in Canada prompted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to assess the species as *Threatened*[*] in 2008. It was subsequently listed on Schedule 1 of the *Species at Risk Act* as a *Threatened* species in 2010. Several provinces followed suit and increased their provincial risk assessments. The Canada warbler is currently considered *Sensitive* in Alberta (Alberta Environment and Sustainable Resource Development [ESRD] 2013); this assessment has remained unchanged since 1996. This status report compiles and summarizes all current information with the goal of updating the status of the Canada warbler in Alberta.

[*] See Appendix 2 for definitions of selected status designations.

SPECIES TAXONOMY

Recent phylogenetic analyses of wood-warblers (family Parulidae) resulted in the reclassification of several species, including Canada warbler (*Cardellina canadensis*), which was formerly in the genus *Wilsonia* along with Wilson's warbler (formerly *W. pusilla*) and hooded warbler (formerly *W. citrina*). These new data resulted in *Wilsonia* being subsumed into two other genera, *Cardellina* and *Setophaga* (Lovette et al. 2010). Canada warbler and Wilson's warbler were determined to be more closely related to the red-faced warbler (*C. rubrifrons*), red warbler (*C. ruber*), and pink-headed warbler (*C. versicolor*). This reclassification was adopted by the American Ornithologists' Union in 2011 (Chesser et al. 2011).

DISTRIBUTION

1. Alberta – Alberta is near the northern and western limits of the Canada warbler breeding range. The species is broadly distributed across the northern part of the province in the Boreal Forest and Foothills natural regions, as well as the Peace River Parkland Natural Subregion near Grande Prairie (Figure 1). Possible breeding records have been reported as far south as Red Deer and Rocky Mountain House (Federation of Alberta Naturalists 2007). The known extent of occurrence of the species' breeding range in Alberta is 376,595 km^2 (Figure 1), which corresponds to 13.7% of the global range (2,756,662 km^2; Berlanga et al. 2010, Panjabi et

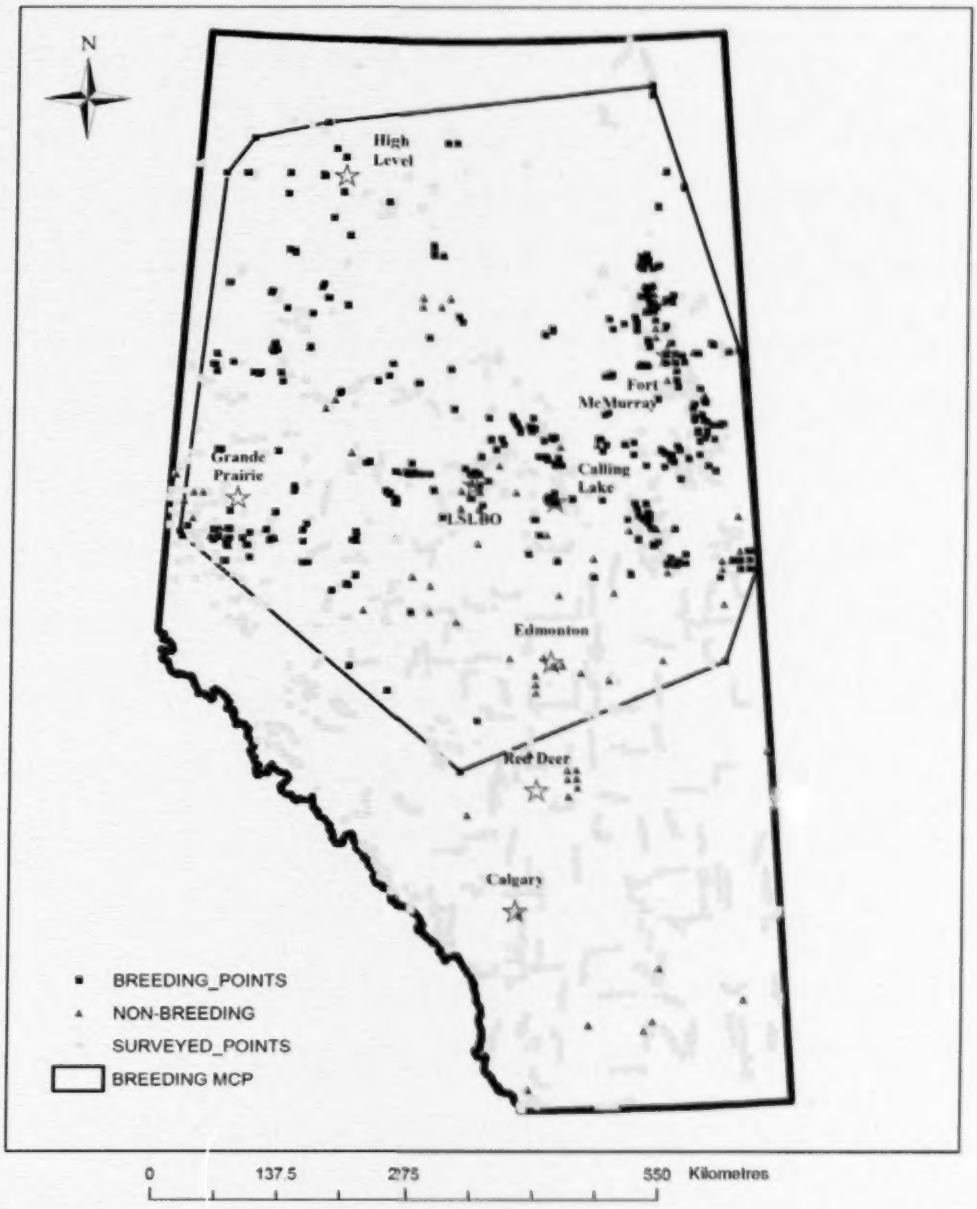

Figure 1. Canada warbler observations within 4-km^2 areas in the province of Alberta. Observations with evidence of breeding are shown as black squares, whereas observations that could not be associated with evidence of breeding are shown as triangles. The minimum convex polygon for all Canada warbler breeding records is shown as a solid black line ("Breeding MCP"; referred to as Extent of Occurrence in the report). Data sources are identified in Appendix 1. Locations surveyed where Canada warblers could have been present but were not detected (light gray squares) are from ABMI, BAM, BBS, and WILDSPACE databases (Appendix 1). Locations of cities and of studies referred to in the text (i.e., Calling Lake, Lesser Slave Lake Bird Observatory [LSLBO]) are indicated with stars.

al. 2012). The extent of occurrence of breeding birds is based on observations of singing males, which are assumed to be evidence of breeding.

Based on all known breeding locations (Figure 1), Canada warblers occupy 1540 km^2 of Alberta (where occupancy is defined as $\geq$ 1 individual detected in a 2-km × 2-km area). Canada warblers are most likely to be found in the Boreal Forest, followed by the Parkland, Foothills and Grasslands, where they are detected much less frequently (Table 1). Despite considerable survey effort, no Canada warblers have been recorded in the Rocky Mountain Natural Region in Alberta (Table 1). There has been too little survey effort to draw any conclusions about Canada warbler use of the Canadian Shield Natural Region, although habitats in this region are predicted to be of low value for this species (Ball et al. 2013). All detections in the Grassland Natural Region and more than 90% of detections in the Parkland Natural Region are banding records from outside the breeding season (approximately 1 June to 15 July; Flockhart 2010). The breeding status of the remaining (< 10%) detections in the Parkland Natural Regions is unknown, but given the limited number of records and large survey effort it seems to be lower quality habitat. By comparison, all or nearly all detections in the Foothills and Boreal Forest natural regions are of singing males from point/transect surveys that are indicative of breeding activity. The Boreal Forest Natural Region also contains many banding records during the breeding season and during migration at Lesser Slave Lake Bird Observatory, where several Canada warbler nests have been located. These data indicate that the majority of Canada warblers breeding in Alberta are in the Foothills and Boreal Forest natural regions and relatively few are likely breeding in the Parkland Natural Region.

The occupancy estimate of 1540 km^2 is based on known locations. It does not account for areas that have not been surveyed and, therefore, should be considered a minimum estimate. For example, only 3.2% of the 166,659 4-km^2 cells in Alberta have had any known survey effort (Figure 1). Several areas of this unsurveyed portion of Alberta are believed to be suitable habitat for Canada warblers (Ball et al. 2013). Future surveys that target areas not previously visited (e.g., remote habitats in the north; Figure 1) will likely result in increased range and occupancy estimates. Sampling effort within each surveyed 4-km^2 area also is highly variable, ranging from a single point to hundreds of points sampled for over 20 years.

Table 1. Numbers of 2-km × 2-km grid cells where Canada warblers have been detected, numbers of cells surveyed, and percentage of surveyed cells occupied in each natural region in Alberta.

Natural Region	# cells occupied	# breeding cells	# cells surveyed	% surveyed cells occupied	% surveyed cells breeding
Parkland	22	1	536	4.1	0.2
Boreal Forest	574	345	2643	21.7	13.1
Foothills	46	25	492	9.3	5.1
Grassland	10	0	1008	1.0	0
Rocky Mountains	0	0	391	0	0
Canadian Shield	4	2	9	44.4[a]	22.2[a]

[a] Most of the data in the Canadian Shield are from observations taken from the Federation of Alberta Naturalists atlas project. In this project, areas surveyed where no Canada warblers were observed were not recorded. With such a small and non-random sampling effort, interpretation of habitat quality in this region should be viewed cautiously as predictive models suggest this region does not likely have a lot of high quality Canada warbler habitat, although some suitable habitat does exist.

Using the habitat suitability model of Ball et al. (2013), we estimated Canada warblers occupied 374,871 km^2 in Alberta during the breeding period. This estimate is based on the number of 2.56 km^2 cells (i.e., one section area; raster cell size of model) that were predicted to support $\geq$ 0.01 males/ha on average. Predicted Canada warbler density was based on forest age, forest type, wetness, topography, and spatial location. This estimate assumes that there are no Canada warblers breeding in the Parkland, Grassland, Canadian Shield, or Rocky Mountain natural regions of Alberta. D. Stralberg (pers. comm.) obtained a similar occupancy estimate of 347,315 km^2 (95% CI: 278,548 – 420,222) using data from a national climate suitability model and the same minimum density threshold of 0.01 males/ha in a 4 km × 4 km cell. These model-based estimates suggest the area occupied in Alberta is 17% – 19% of that occupied in North America during the breeding season (Stralberg et al. 2013; D. Stralberg pers. comm.). It is important to note that these model estimates have not been validated with data independent of the data used to construct the model. Such validation is needed to ensure these estimates are accurate. Regardless, these model-based estimates suggest that the area occupied is potentially much larger than the current estimate based on known locations.

There are insufficient data to indicate whether the extent of occurrence and area of occupancy in Alberta vary annually or have decreased in the past; however, it is possible that extent of habitat may decrease in the future, if agricultural expansion in the southern boreal forest continues and climate change results in loss of forest (see Population Size and Trends, and Limiting Factors for further discussion). There also is no indication that the population is either severely fragmented or separated into distinct subpopulations or locations (the latter defined as distinct areas within which all the Canada warblers would be affected by a single threatening event). Instead, Canada warblers are continuously distributed across northern Alberta with local abundance varying in relation to habitat quality, which is primarily a function of forest stand composition, stand age, wetness, and topography (Ball et al. 2013). Because habitat suitability is positively associated with forest age, occupancy can be expected to increase in stands within the current range that remain undisturbed by natural or human processes (e.g., Vernier et al. 2009) (but see Limiting Factors for further discussion).

2. Other Areas – The Canada warbler breeding range extends across the northern forested region of North America from southeastern Yukon and northeastern British Columbia to Nova Scotia, extending southward into the United States in forested regions around the Great Lakes and the northeast, and extending southward at higher elevations of the Appalachian Mountains to northern Georgia (Figure 2; Ridgely et al. 2003, Reitsma et al. 2010). Canada warblers typically winter on the eastern slope of the Andes Mountains in northern South America. Their winter range extends from Venezuela in the northeast to Ecuador and central Peru in the southwest with rare records ranging as far north as Costa Rica and as far southeast as the Amazon region of Brazil (Figure 2; Reitsma et al. 2010).

Habitat loss on the breeding and wintering grounds is considered the primary threat to this species (Reitsma et al. 2010, NatureServe 2013a; see Limiting Factors section). The extent and area occupied would be expected to decline in response to habitat loss and alteration, although we are not aware of any estimates of historical or predicted changes in extent or area occupied. Canada warblers use early successional forests, particularly in the eastern portion of their breeding range, and moderately disturbed habitats on their wintering grounds (see Habitat section), which may buffer their sensitivity to some land uses in some areas. Recent detections in British Columbia suggest the species is expanding the western edge of its range (Cooper et al. 1997).

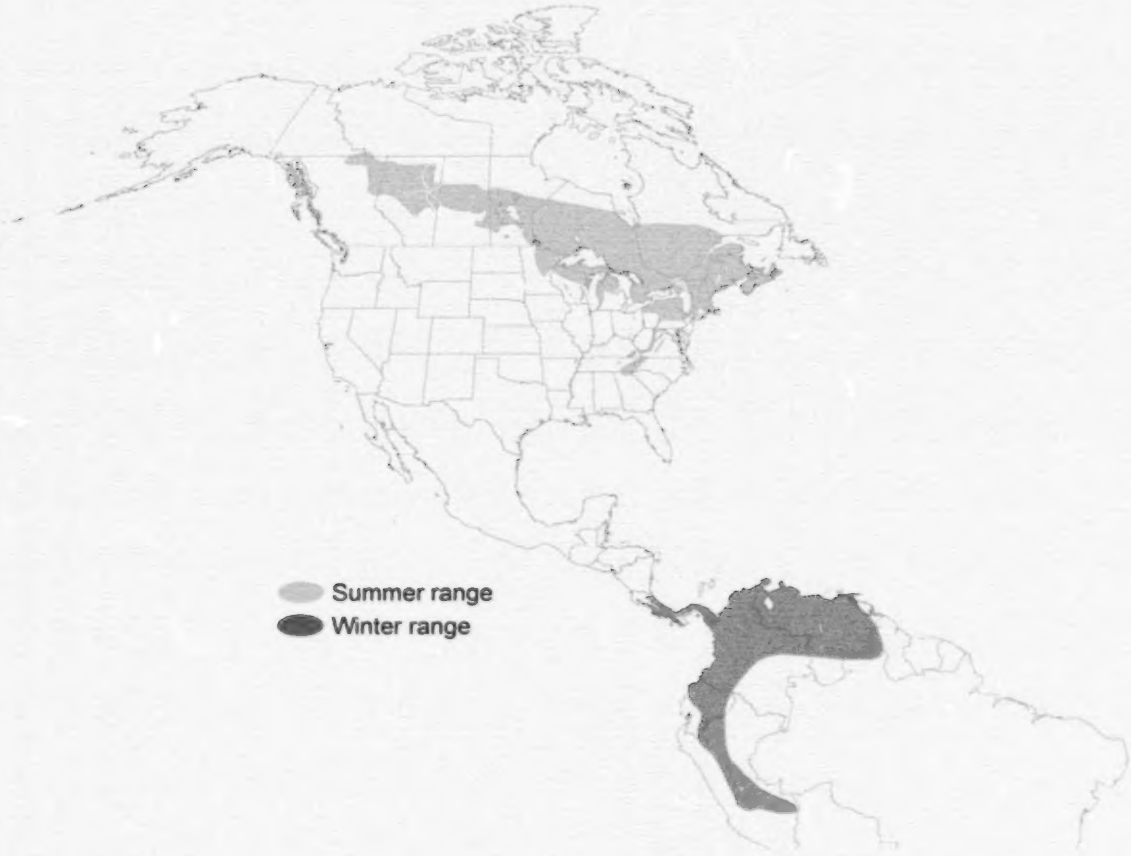

Figure 2. Breeding and wintering ranges of Canada warbler (based on COSEWIC [2008] and NatureServe [Ridgely et al. 2003] in collaboration with Robert Ridgely, James Zook, The Nature Conservancy [Migratory Bird Program], Conservation International [CABS], World Wildlife Fund [US], and Environment Canada [WILDSPACE]).

Surveys targeted at delimiting the extent of their northwestern range appear warranted. Range expansion also may have occurred in the northeastern United States during the early to mid-1900s in response to an increase in forested cover on previously agricultural land (Reitsma et al. 2010). Continued forest maturation in the northeastern United States, along with increased deer browse and loss of forested wetlands, has resulted in loss of suitable habitats in this region.

HABITAT

The majority (> 90%) of the Canada warbler breeding population inhabits northern forests (Berlanga 2010, Panjabi et al. 2012). Habitat associations of Canada warbler have been well described in eastern regions and in relation to forest harvesting and fire in Alberta. Habitat associations vary by region, but throughout their range Canada warblers are most commonly found in moist to wet habitats with a dense understory, which may be important for foraging and nesting success (Schieck et al. 1995, Lambert and Faccio 2005, Hallworth et

al. 2008a, 2008b, Chace et al. 2009, Flockhart and Krikun 2012).

1. Local and Landscape Scales – In western regions, including Alberta, Canada warblers are most commonly associated with stands of pure deciduous or deciduous-dominated old-growth forest on steep slopes adjacent to incised streams and small rivers (Schieck et al. 1995, 2000, Kirk et al. 1996, Norton et al. 2000, Vernier et al. 2009, Flockhart and Krikun 2012, Ball et al. 2013). Old-growth is defined as forest that is more than 125 years post-disturbance (Lee 2002). Canopy trees achieve their maximum size and density during this stage. Trees from the original cohort also begin to grow old and fall, which results in the accumulation of downed woody material on the forest floor and, in mixedwood stands, a gradual replacement of deciduous canopy trees with slower-growing conifer trees. These fallen trees leave large gaps in the forest canopy, which in turn allows more sunlight to reach the forest understory that promotes vertical stratification through accelerated growth of the sub-canopy and shrub layers, and increased density and diversity of vascular plants on the forest floor (Lee 2002).

Canada warblers also inhabit alder (*Alnus* spp.) and willow (*Salix* spp.) thickets (Flockhart and Krikun 2012). Abundance declines as the proportion of conifer trees in the canopy increases in Alberta (Norton et al. 2000, Ball et al. 2013), but small proportions of white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) in the canopy are preferred in northeastern British Columbia (Cooper et al. 1997). Agriculture and urban-industrial habitats are avoided (Ball et al. 2013).

In the larger landscape, Canada warbler abundance is positively associated with the amount of deciduous forest of any age and negatively associated with the amount of black spruce (*P. mariana*) (Vernier et al. 2009, Norton et al. 2000, Ball et al. 2013). The habitat model developed by Ball et al. (2013) did not show strong support for differences in Canada warbler abundance in areas with differing densities of energy sector linear features (i.e., seismic lines, pipelines, and service access roads) and well-pads. The availability of suitable habitat generally increases from south to north and from east to west within the boreal forest of Alberta, but suitable habitat exists in the south and east where favourable conditions exist, irrespective of the general spatial trend (Ball et al. 2013).

Canada warblers also have been recorded in early seral stages of trembling aspen (*Populus tremuloides*) in Alberta, albeit at much lower densities compared to old-growth forest (Schieck et al. 1995, 2000, Kirk et al. 1996, Schieck and Hobson 2000, Schieck and Song 2006). Canada warblers are generally absent from recently disturbed stands, particularly those without live residual trees (0 – 10 years post-disturbance; Schieck et al. 1995, Kirk et al. 1996, Norton et al. 2000, Schieck and Song 2006). Densities in adjacent habitats may increase the first year after disturbance as displaced individuals crowd into remaining suitable habitats (Song 1998). However, densities return to pre-disturbance levels the following year, suggesting displaced individuals disperse from the area. Canada warbler abundance in regenerating stands generally peaks at 11 to 30 years post-disturbance and their numbers decline to rare or uncommon as residual trees senesce and disappear from the canopy (31 – 75 years post-disturbance; Hobson and Schieck 1999, Kirk et al. 1996, Schieck and Song 2006). Numbers of Canada warbler increase thereafter as stands continue to mature into the preferred older age classes.

Harvested stands with patches of live residual trees and a dense shrub layer are generally preferred relative to burned stands that commonly lack these features (Schieck and Hobson 2000, Schieck and Song 2006).

Abundance in early seral habitats is positively correlated with amount of tree retention and residual patch size. Canada warblers were absent from harvested stands when residual retention was 6%, but were present when residual retention was between 30% and 40% and was aggregated into larger patches (Norton and Hannon 1997, Schieck et al. 2000, Schieck and Hobson 2000). The role of residual patches too small to contain a territory is unknown. Previous researchers have suggested that emergent trees are important perches for territorial displays (Hallworth et al. 2008a, Chace et al. 2009). However, aggregated residual patches are preferred to single trees that could function as suitable song perches, which suggests the presence of a canopy may be an important habitat component that determines where birds settle (Norton and Hannon 1997, Schieck et al. 2000, Schieck and Hobson 2000). Alternatively, adult Canada warblers tend to use edges, either natural or man-made (Cooper et al. 1997, Reitsma et al. 2010; D. T. T. Flockhart pers. comm.), and they may select for residual forest patches that provide suitable habitat contrasts or understory composition or structure near their margins.

At a coarse level, there is a large amount of deciduous-dominated forest in the Boreal Forest Natural Region of Alberta where Canada warblers likely can breed. However, specific habitat attributes such as dense shrub cover in incised wet areas are rarer. Importantly, there is no easy way to map the density of shrubs in Alberta at this time, which precludes a direct estimation of "suitable but not occupied" habitat. Suitable habitat for the Canada warbler in Alberta can be predicted from a model that includes the following predictor variables: forest age, forest type, wetness, topography, and spatial location (Ball et al. 2013).

In the eastern portion of their range, Canada warblers are commonly associated with forested swamps and riparian areas under a closed or semi-open mixed canopy with a naturally dense understory (Lambert and Faccio 2005, Hallworth et al. 2008a). Canada warblers also are commonly associated with early seral upland habitats where natural or human disturbance has opened the forest canopy allowing a dense understory to develop; they are often referred to as an early successional species in this region (Drapeau et al. 2000, Hagan and Meehan 2002, Faccio 2003, Lambert and Faccio 2005, Chace et al. 2009, Becker et al. 2012). Residuals are also important in eastern disturbed landscapes, which are occupied by Canada warblers at an earlier age (5–20 years post-disturbance) compared to western landscapes. However, these disturbed upland forests may be lower quality habitat compared to wet forests and they are abandoned when the understory becomes taller than six metres (Hagan and Meehan 2002, Hallworth et al. 2008a).

2. Nest Site – The nest is a bulky cup of dry leaves, bark, twigs, grass, plant fibres, and animal hair (Cooper et al. 1997, Reitsma et al. 2010). Nests are located on or near the ground typically in a well concealed location, such as beneath or within root masses, rotting stumps, logs, rocks, mossy hummocks, brush piles, clumps of grass, or small hillocks with deep litter and dense saplings. There is no information regarding nest site limitation.

3. Winter – Canada warblers select habitats with dense understory in the foothills, mountains, and lowlands adjacent to the east slope of the Andes. They are found in primary (unharvested) forest, but are tolerant of moderate levels of disturbance and also found in young and old secondary (regenerating) forests, forest edges, scrub habitats, semi-open areas, and coffee plantations between 500 m and 2000 m above sea level (Komar 2006, Reitsma et al. 2010, Davidson et al. 2011). In Colombia, Canada warblers were not found in landscapes with less than 20% regional forest cover (within 1 km^2) and they were virtually absent from stands with a degraded understory and less than 45% canopy cover (Colorado

2011). The survival consequences of using disturbed habitats versus primary forest are unknown.

CONSERVATION BIOLOGY

The Canada warbler is a medium-sized, neotropical migrant wood-warbler. Males are readily identified by their slate-grey back, yellow underparts, black necklace, and prominent supraloral stripe and eye ring that give the appearance of spectacles (Reitsma et al. 2010). Females appear similar to males, although they are duller in colour overall. Despite their broad distribution and characteristic appearance, Canada warblers have been the focus of few research studies, particularly in the western portion of their range, and many aspects of their breeding biology are not well known.

1. Migration and Breeding Phenology – Canada warblers have a short breeding period compared to other wood-warblers (Flockhart 2007). They are one of the last warblers to arrive on their northern breeding grounds. In Alberta, older males arrive at Lesser Slave Lake Bird Observatory by 1 June on average and are two to three days ahead of females and younger males (Flockhart 2007). Earlier arrival may allow older males to settle in higher quality habitats (Hallworth et al. 2008a, 2008b). Territory establishment and pairing happen quickly, and initiation of breeding (mean date of first egg laid = 11 June) and moulting (mean = 12 July) are synchronized with other warbler species in the region (Flockhart 2010). This synchrony may reflect an evolutionary constraint to match the energy demands of reproduction with peak food abundance and to avoid provisioning nestlings during moult, which is a critical stage in the annual cycle requiring time and energy for adults to complete. Moult initiation begins immediately after nestlings fledge (mean = 11 July). Duration of moult for Canada warblers in Alberta is approximately 28 days, which is 2 – 41 days shorter than other wood warbler species monitored at Lesser Slave Lake (Flockhart 2010). Female Canada warblers depart the breeding grounds on their southward migration two days after completing their moult (mean = 4 August). Hatch-year birds depart two to four days after females and males depart last, approximately eight days after females (mean = 12 August). Individuals defend winter territories and birds may depart early to secure space in high quality habitat (Rohwer et al. 2005). In total, males and females spend an average of 72 days and 62 days, respectively, on the breeding grounds (Flockhart 2007). This contracted breeding period may pose significant time and energetic constraints on breeding, re-nesting opportunities, moult, and survival, particularly for females (Flockhart 2007).

2. Reproductive Behaviour – Canada warblers build an open cup nest on the ground, typically in dense vegetation. In eastern portions of their range, nest success is positively associated with concealment by complex ground vegetation and shrub density (Goodnow and Reitsma 2011). Canada warbler nests are frequently parasitized by brown-headed cowbirds (*Molothrus ater*) in some areas, and dense understory vegetation may be important to reproductive success by providing protection from nest predators and cowbirds (Reitsma et al. 2010). Parents also sit tight on the nest when approached by observers, which suggests adults may actively defend their eggs and nestlings from predators and cowbirds, or attempt to conceal their nest's contents with their slate grey back (Goodnow and Reitsma 2011). Brood parasitism by cowbirds is uncommon in the boreal forest of Alberta, except in landscapes with an extensive agricultural matrix (Hannon et al. 2009, Ball et al. unpubl. manuscript). Red squirrels (*Tamiasciurus hudsonicus*) are the dominant nest predator in Alberta's boreal forest and nest concealment does not affect their rate of nest predation (Ball et al. unpubl. manuscript). Together this suggests a dense understory may be less important to nest site selection in Alberta. Nestlings fledge approximately eight

days after hatch (before they can fly), and they remain in the vicinity of the nest for the first few days post-fledging (Reitsma et al. *2010*). A dense understory also may be important for concealing fledglings and moulting adults from predators during this vulnerable period (Chace et al. 2009). No records exist for the post-fledging period of Canada warblers in Alberta. Fledglings achieve flight within two to three days and gain independence within two weeks after fledging.

3. Diet and Foraging Behaviour – Canada warblers forage primarily on flying insects, but their diet also includes beetles and non-flying arthropods such as caterpillars and spiders (Reitsma et al. 2010). They forage in a wide range of microhabitats within low branches of deciduous and coniferous trees and shrubs of varying heights, and they employ a variety of foraging methods (Sohdi and Paszkowski 1995, Reitsma et al. 2010). Adults provision nestlings with larval and adult lepidoptera, diptera, and spiders (Reitsma et al. 2010, Flockhart and Krikun 2012). Local abundance of Canada warblers may be positively associated with larval biomass in years of low prey abundance, which suggests this is an important food resource during the breeding period (Song 1998).

4. Demography and Dispersal – Canada warblers begin breeding at one year of age (Reitsma et al. 2010). Females typically lay a single clutch of four to five eggs (range = 2 – 6) and fledge an average of 3.8 young/nest (Reitsma et al. 2010). The proportion of nests that are successful is not known. Reitsma et al. (2010) report a daily nest survival rate of 0.9555 for 37 nests. The probability of a nest surviving from hatch to fledge is 0.32 ($[0.9555]^{25\ days}$), assuming a constant probability of daily survival, a five-egg clutch with one egg laid per day, a twelve-day incubation period, and an eight-day nestling period. Canada warblers are not known to attempt a second brood if the first nest is successful, but they will attempt to re-nest if the first nest fails early in the breeding season (Reitsma et al. 2010).

The average age of breeding adults and adult survivorship are not known. Reitsma et al. (2010) report that four-year-old males are common in a New Hampshire breeding population and that several individuals were known to be older. The average return rate for males is 52% in this region, which suggests apparent survival is high in good quality habitat (Hallworth et al. 2008a). Estimates of apparent survival are typically lower than true survival because they do not account for the fate of emigrants. However, across all habitats, true survival in this region may be less than 52% if site fidelity is high in high quality habitats (i.e., most birds that fail to return are dead) and apparent survival is low in poorer quality habitats. The oldest known individuals from banding records were 8.0 years (Quebec) and 7.92 years (New York; North American Bird Banding Program 2013). Juvenile survival is also unknown, but is commonly considered to be half that of adult survival for passerine birds (Ricklefs 1973).

Little is also known about dispersal of adults and juveniles. Banding records provide little insight because of extremely low capture rates for this species; 0.05% of the 95,542 Canada warblers banded in North America from 1960 to 2013 have been recaptured (North American Bird Banding Program 2013). One individual of the 3059 banded in Alberta has been recaptured, which occurred during spring migration in Minnesota (R. Krikun pers. comm.). No birds that have been banded elsewhere have been recaptured in Alberta (R. Krikun pers. comm.). Brewer et al. (2006) report that, of the 10,767 Canada warblers banded in Canada between 1955 and 1995, only nine (0.08%) have been re-sighted with a maximum movement of 946 km between encounters. Most of these (6 of 9) were originally banded in the United States during migration. Only two Canadian-banded birds were recaptured elsewhere with

a mean distance of 18 km between encounters. A telemetry study conducted on fledglings in New Hampshire suggests dispersal distance is highly variable with some fledglings leaving the study area within a week of departing the nest and others remaining for the life of the transmitters (Reitsma et al. 2010).

POPULATION SIZE AND TRENDS

1. Alberta – Canada warblers are relatively uncommon and, particularly in the west, they are broadly distributed across remote areas with limited access. Estimates of population size and trend are hampered by limited data in western regions, including Alberta. The current population of Canada warblers in Alberta reported in *The General Status of Alberta Wild Species 2010* is estimated to be between 2000 and 10,000 individuals (ESRD 2013). More recent estimates based on the latest statistical advances and a data set compiled over numerous years and studies suggests the population size is between 0.2 and 2.4 million breeding males (see below). Population size is estimated for breeding males because the standard survey protocol targets singing individuals and for most species of songbirds, including Canada warbler, only territorial breeding males sing. Management decisions based on total population size that is derived by doubling the number of breeding males should be conservative to reflect uncertainty in the ratio of females to males in the breeding population. The ratio of females to males could be less than one if energetic constraints on the breeding grounds (see Conservation Biology) and sexual habitat segregation on the wintering grounds (e.g., Marra and Holmes 2001) have disproportionately high survival costs for females. The proportion of non-breeding adults (i.e., "floaters") in the population is also unknown.

Based on a national climate suitability model built to exclude non-habitat (agriculture, urban development, water, and unforested wetlands), there are an estimated 773,758 (95% CI: 636,532 – 910,984) adult male Canada warblers in Alberta (D. Stralberg unpublished results based on methods in Stralberg and Bayne 2013). This climate suitability model includes seven variables that are direct or derived measures based on temperature and precipitation. Using this same method, Stralberg estimated the breeding population in Alberta to represent 11% (95% CI: 8% – 13%) of the global breeding population. Using similar bird data, but a more detailed model that included a greater number of environmental predictor variables, Ball et al.'s (2013) model estimated that the number of adult male Canada warblers in Alberta could be as high as approximately 2.41 million.

Both the Stralberg and Bayne (2013) and Ball et al. (2013) models use new statistical advances to correct for detection error and detection radius as per Boreal Avian Modelling Program protocols (www.borealbirds.ca; hereafter BAM density). BAM density results in much higher estimates of density and therefore population size than the current Partners in Flight standard (hereafter PIF). In short, BAM computes density using distance estimation and corrects for singing rates. The distance estimation function computes the effective detection radius, which is the distance at which the probability of missing a bird within that distance is the same as the probability of detecting a bird outside that distance. In essence, this effective detection radius provides the area over which a point count is divided to convert a count to density. PIF uses an alternative and much more conservative approach based on the maximum detection distance that Canada warblers can be heard during a point count (Rosenberg and Blancher 2005). For Canada warbler, this distance is 125 metres; however, this is conservative density correction for a forest environment because bird vocalizations can be heard over greater distances when surveying from a road, which is the reason the PIF density estimator is so much lower than BAM. Using the approach of Matsuoka et al. (2012) to

convert the BAM density estimates of Stralberg and Bayne (2013) and Ball et al. (2013) to PIF density estimates, the number of breeding male Canada warblers in Alberta is roughly between 202,000 and 630,000, respectively. Using raw data from the Alberta Biodiversity Monitoring Institute (ABMI) for the province of Alberta, the mean number of Canada warblers detected per point count station is estimated to be 0.021 ± 0.172 birds (n= 8630 stations). Converted to density using PIF and assuming ABMI's data are a random sample of the province, there are an estimated 287,500 male Canada warblers in Alberta. Using the BAM approach, the same data results in a population estimate of 1.26 million.

Numbers of Canada warblers detected on Breeding Bird Surveys (BBS) in Alberta have steadily declined by 3.74%/year (95% credible interval: -7.80 – -0.262) between 1975 and 2012 (Environment Canada 2013; Figure 3). This represents a 76% decline in the population over a 37-year period. However, the detection rate per BBS survey route is low and the average annual difference amounts to a decline of 0.015 individuals/route/year. The long-term trend is consistent with the latest 10-year period (2002 – 2012: -4.74%/year [-15.0 – 2.0]) or 38.5% total decline. The latest five-year trend is not provided. However, the annual indices in Alberta have continued to decline and the rate of decline over the most recent five years appears roughly similar to the ten-year trend (Environment Canada 2013; Figure 3). Based on the above 10-year annual rate of change, the estimated total decline over the most recent five-year period is -21.6%. The numbers detected annually per route do not exhibit extreme fluctuations (Figure 3).

The trend based on BBS data should be interpreted with caution because most survey routes in Alberta are located along major roadways in the southern boreal and do not cover the majority of the species' range in the province, which has not been adequately surveyed (see Distribution). The BBS data are meant to represent the trend of Canada warbler at larger scales rather than local populations, assuming the sampled population represents the larger population (i.e., the population in Alberta, for the purposes of this report). For example, a long-term study that has monitored songbirds annually since 1993 at Calling Lake, Alberta, has detected a substantive increase in the number of Canada warblers beginning around 2007, which has resulted in an approximately 250% increase in the size of the local Canada warbler population. The cause of the increase at Calling Lake is not known, nor is it known whether this is an anomaly or if local populations are increasing elsewhere in the province. Further surveys targeted at the Canada warbler are needed to reconcile these disparate results, and determine if forest succession has allowed the development of old-growth, providing suitable localized habitat for Canada warblers.

There is no evidence to suggest the current provincial trend will not continue over the next 5- to 10-year period. However, the potential does exist in some regions for short-term improvements in habitat quality and increased occupancy if the species is limited by the availability of suitable habitat in the province. For example, mature and old-growth forests that provide suitable habitat for Canada warblers in Alberta-Pacific Forest Industry Inc.'s Forest Management Area (hereafter, ALPAC FMA) in northwestern Alberta are predicted to increase for the next 30 years as forest succession results in the maturation of stands originally disturbed by fires that occurred in the 1920s and 1930s (Schneider 2002, Vernier et al. 2009, ALCES Group 2011). However, the area of mature and old forest habitats (hardwood, mixedwood, white spruce, pine, hygric softwood/black spruce) under a current harvest and energy sector development scenario and a 20% protected area scenario within the ALPAC FMA will decline sharply over the next 100 years (Mahon et al. 2014). Specifically, old

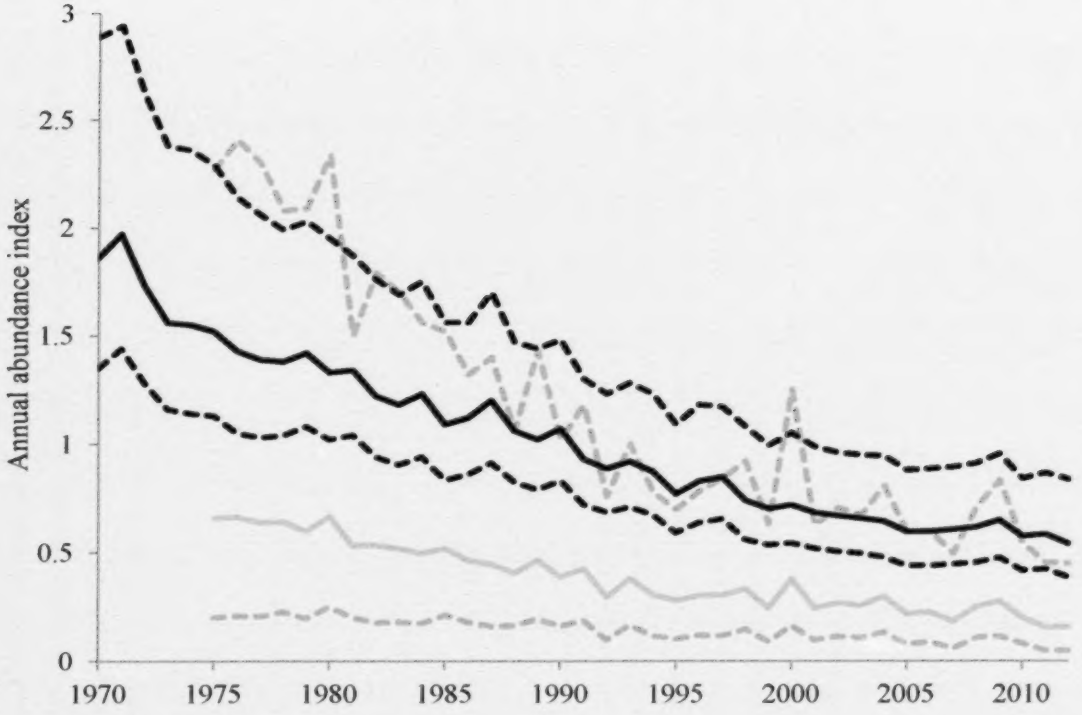

Figure 3. Average number of Canada warblers detected per Breeding Bird Survey route in Alberta (grey lines) and in North America (black lines; Environment Canada 2013). Solid lines represent average values and dashed lines represent 95% credible intervals (Environment Canada 2014).

hardwood and mixedwood (older than 80 years) declined to below current levels by year 30 in their simulation. Additional management strategies that include exclusion of some old-growth forest from harvest may be necessary to protect suitable habitats (ALCES Group 2011). Fire suppression also may be necessary if the frequency of forest fires increases with climate change in the future (ALCES Group 2011). Opportunities currently exist to conserve habitats that are, or will soon be, suitable for Canada warblers in the ALPAC FMA and in other FMAs in the province that have maturing forest stands that are becoming increasingly suitable for Canada warblers.

2. Other Areas – Based on a national climate model, D. Stralberg (pers. comm.; Stralberg et al. 2013) estimated a current global Canada warbler population of 7.3 million individuals (95% CI: 6.5 million – 8.1 million). This is nearly double the most recent PIF estimate of 4 million individuals (Partners in Flight Science Committee 2013). Much of this difference is explained by the underlying statistical assumptions made by PIF versus BAM approaches. Converting Stralberg et al. (2013) estimates to PIF estimates using maximum detection distance gives population estimates from 1.91 to 4 million Canada warblers. Regardless, both approaches provide similar estimates of the relative percentage of the breeding population estimated to occur in Canada (Stralberg pers. comm.: 78% [68 - 90]; Panjabi et al. 2012: 82%).

Numbers of Canada warblers detected between 1970 and 2012 have declined 2.9%/year (95%

credible interval: -4.07 – -1.78) or 71% overall across their North American breeding range (Environment Canada 2013; Figure 3). The trend during the most recent 10-year period was -1.95%/year (-4.08 – 0.901), which amounts to a 25.5% decline overall. The latest five-year trend is not provided, but annual indices in North America appear to have declined less in recent years (Environment Canada 2013; Figure 3). Declines are more prominent in the east and during years prior to the mid-1990s, whereas populations are increasing in the Appalachian Mountains and around the Great Lakes. Historically, the decline in the east may have been driven by loss or degradation of forested swampland (Hallworth et al. 2008b) and by the maturation of upland forests on former agricultural lands so that they were no longer suitable habitat (Reitsma et al. 2010). It is not clear why the rate of decline has slowed during the last decade, but continued land use may be creating suitable early successional habitats in some eastern regions. There are no global population projections for the next 5 to 10 years.

3. Rescue Potential – Although Canada warblers are declining across their range, numbers in Saskatchewan are increasing (Environment Canada 2013) and range expansion is occurring in British Columbia (Cooper et al. 1997). Furthermore, the recent appearance of Canada warbler in British Columbia (Cooper et al. 1997) and the increase in numbers at Calling Lake (E. M. Bayne and F. K. A. Schmiegelow, unpubl. data) suggest immigration is possible and that these immigrants are adapted to survive in newly-settled habitats. Together, these data suggest rescue of Alberta populations from adjacent regions is possible if suitable habitat in Alberta is available to be settled. Declines in the numbers of Canada warblers in Alberta are hypothesized to be caused, at least in part, by declines in the quantity or quality of breeding habitat within the province (see Limiting Factors section). This suggests potential immigrants to Alberta might not find vacant suitable habitat. The increase in numbers of Canada warblers at Calling Lake suggests that suitable vacant habitat is available there, possibly as a result of succession and the development of old-growth stages, and that it is being settled by local recruits or by immigration from outside the local area. These improvements in habitat quality at Calling Lake and in the ALPAC FMA will be short-lived without changes to current land-use practices.

LIMITING FACTORS

Reasons for the decline in Canada warbler populations are not known, but loss and deterioration of habitat on the breeding and wintering grounds are considered to be the primary causes. Permanent loss of forest to development, particularly along the southern fringe of the boreal forest, is the biggest threat to birds in the western boreal forest (North American Bird Conservation Initiative 2012). Wells (2011) estimated that 24% of the breeding distribution of Canada warblers in the Canadian boreal forest was within areas impacted by anthropogenic disturbance, while only 7% of its distribution was within protected areas. This lack of protection may represent a threat to the persistence of Canada warblers in Alberta, depending on how land outside of protected areas is managed. Other known or potential threats (listed in likely order of immediate severity and discussed below) include increased rates of nest predation and brood parasitism because of habitat fragmentation, climate change, over-browsing of understory vegetation by deer, and declining spruce budworm (*Choristoneura fumiferana*) biomass.

1. Loss and Fragmentation of Breeding Habitat – Habitat conversion that results in loss of old-growth deciduous forest and forested riparian areas at the local scale and loss of deciduous forest at the landscape scale is reasonably expected to negatively impact Canada warbler in Alberta (Ball et al. 2013).

Areas of Alberta's forests that are under the greatest development pressure that also have been identified as having suitable Canada warbler habitat are the eastern part of the province from highway 16 south of Cold Lake to north of Fort McMurray, north of Whitecourt, north and west of Grande Prairie, and east of Peace River (Lee et al. 2009 [p.87], Ball et al. 2013). As of 2010, 21% of Alberta's Boreal Plains Ecozone, which composes the majority of Alberta's northern forests and encompasses 90% of Alberta's oil sands region, has been directly altered by human activity, more than half of which constitutes habitat loss to agriculture (Alberta Biodiversity Monitoring Institute 2012). Oil sands extraction activities that result in loss of forest cover also may negatively impact Canada warblers. Restoration of mined oil sands habitats from peatland to incised, upland forests in the northeastern portion of the province may benefit Canada warblers when these forests mature, if appropriate shrub and soil moisture/topography conditions are taken into account (Rooney et al. 2012).

Canada warblers are strongly associated with deciduous landscapes and old-growth deciduous stands near incised streams. Current harvest strategies are meant to replicate a natural disturbance regime, which, in Alberta's boreal forest, is primarily fire. However, harvesting selectively targets old-growth stands, whereas fire generally affects all age classes (Cyr et al. 2009, Lee et al. 2009). The result is that older age classes are under-represented and young age classes are over-represented on the landscape compared to a landscape without human impact. Harvesting and regeneration strategies that increase the vigour and representation of coniferous trees at early stages of succession, at the expense of deciduous trees (Lieffers et al. 2008), will contribute to a loss or reduced duration of older deciduous-dominated forest stages, and therefore may reduce the amount of suitable habitat available to Canada warblers. The Alberta Biodiversity Monitoring Institute (2012) estimates that deciduous trees have declined by 32% and old-growth deciduous trees have declined by 50% compared to landscapes with no evidence of human impact. Current forestry and oil and gas practices are predicted to increase the anthropogenic footprint and reduce older forests, and this loss of old forest is predicted to cause declines in Canada warbler numbers (Carlson et al. 2009). This scenario has already played out in Europe, where forestry has nearly eliminated old forests from the landscape and many of the species that depend on these forests are now threatened (Cyr et al. 2009). Conservation planning aimed at Canada warbler needs to ensure sufficient old-growth deciduous habitat is retained.

Old-growth deciduous trees are retained as residuals in harvested stands and as buffers along streams. Current buffer widths along riparian corridors (10 m – 60 m; Alberta Sustainable Resource Development 2008) may be too narrow to function as habitat. For example, Lambert and Hannon (2000) found that ovenbirds (*Seiurus aurocapillus*) were absent from 20 m riparian buffer strips post-harvest. Small, intermittent streams have no treed buffer requirement in Alberta. Vernier et al. (2009) suggest that a minimum residual patch size of 100 ha is necessary for Canada warblers. Further study is needed to determine what types of streams and buffer characteristics (e.g., Braithwaite and Mallik 2012) constitute preferred habitats, and such work is being undertaken by E. Bayne of the University of Alberta in collaboration with Lesser Slave Lake Bird Observatory. Increasing the size of residual patches not associated with riparian areas and using site preparation techniques that encourage deciduous tree growth would also benefit Canada warblers.

Canada warbler density is negatively affected by the amount of industrial development at both the local and landscape scales (Ball et al. 2013, Haché et al. 2014, Sólymos et al. 2014). This decline in density as the industrial footprint increases likely reflects a loss of suitable habitat

rather than an avoidance of anthropogenic features. For example, Machtans (2006) found that territory placement was unaffected by seismic lines. Instead, lines were included within the defended space and were treated as unusable habitat and territory size was increased accordingly. Boreal forest birds, and birds in forested systems in general, are buffered against negative fragmentation effects when an extensive amount of forest is retained on the landscape (Schmiegelow et al. 1997, Norton et al. 2000, Betts et al. 2006). Because Canada warblers will establish territories in early seral habitats, albeit at much lower densities compared to old-growth forests, and use scrubby habitats on the wintering grounds, harvesting is not expected to restrict dispersal through fragmented landscapes so long as some shrub or sapling cover is present.

2. Loss and Fragmentation of Wintering Habitats – Loss and degradation of habitat on the wintering grounds are considered to be important factors contributing to the decline of Canada warblers (COSEWIC 2008, Reitsma et al. 2010). The forests of the northern Andes Mountains continue to be developed to serve the growing human population in the region (Davis et al. 1997, Robinson 1997, Davidson et al. 2011). Forest cover in this region continues to be lost at 50,000 to 500,000 hectares/year (Food and Agriculture Organization 2010). Only 15 of the 68 terrestrial regions in the Andean-southern Cone region, which includes the area occupied by Canada warblers, are considered relatively stable (Roca et al. 1996). Winter territories are defended against conspecifics, which suggests the availability of suitable habitat may be limited.

3. Human Impacts on Nest Predation and Brood Parasitism Rates – Nest predation is a primary cause of reproductive failure for many songbirds (Ricklefs 1969). Increased rates of nest predation and brood parasitism in fragmented landscapes, particularly near habitat edges, have been implicated in contributing to the declining numbers of some species (Robinson et al. 1995). These negative fragmentation effects are commonly reported in eastern North America and in landscapes with an extensive agricultural matrix (George and Dobkin 2002). Alberta's boreal forest has a largely forested matrix and a nest predator community composed of endemic species that do not respond positively to edge habitats resulting from forest fragmentation (Ball et al. unpubl. manuscript). Therefore, Canada warbler nests that are in fragmented boreal landscapes and nests nearer to forest edges are unlikely to experience elevated rates of nest predation. Brown-headed cowbirds are rare across most of the boreal region and nest parasitism is not a concern except along the southern fringe of the boreal forest where there are significant amounts of agriculture on the landscape (Hannon et al. 2009). Canada warblers are frequently parasitized by cowbirds in some regions (Reitsma et al. 2010), so Canada warblers could be adversely affected by parasitism in forests near agriculture and by agriculture expansion in Alberta.

4. Climate Change – Climate change is predicted to change the distribution of Alberta's forests, particularly in the latter half of this century (Schneider 2013). A substantial portion of habitats ranked as being most suitable for Canada warblers are roughly located in the Central Mixedwood and Dry Mixedwood natural subregions of the Boreal Forest Natural Region (Ball et al. 2013). These regions are predicted to transition to parkland then grassland habitat, which will shrink and fragment the remaining forest habitats (Schneider 2013). The rate and extent of habitat conversion will depend on the amount of drying and changes in the fire frequency (Schneider 2013). Permafrost underlying the Northern Mixedwood Subregion is expect to significantly delay the transition of this region to suitable Canada warbler habitat, which is not expected to transition beyond a wetland stage dominated by bogs and fens before the end of the century

(Schneider 2013). The Boreal Highlands are predicted to transition into habitats similar to the current Central Mixedwood. Based on the averaged estimates from 19 global climate models, the current Canada warbler range in Alberta is predicted to contract and shift upslope into the Boreal Highlands over the coming century (Stralberg and Bayne 2013). Numbers of Canada warbler in the province are predicted to decline 2% (± 16% [2 SE]) by 2040 and by 45% (± 20%) by the end of the century. In contrast, corvids associated with agriculture are predicted to increase which, combined with fragmentation, could further increase the predicted Canada warbler declines through increased rates of nest predation. Nationally, Canada warblers are predicted to increase in response to climate change with the largest increases (46% ± 29% [2 SE]) occurring in the Northwestern Interior Forest and Taiga Shield and Hudson Plains by the end of the century (Stralberg et al. 2013). The predicted increase in numbers of Canada warbler (and the predicted decrease above) is in response to the predicted change in local climate. Local climate is considered a major driver of local habitat conditions and the predicted increase in Canada warblers is in response to an increase in the amount of suitable habitat available on the landscape. However, it is important to note that there is a large amount of uncertainty in how climate is going to change and in how and when habitats will respond to that change. Additionally, these climate models do not account for increased rates of development in the boreal forest, which will further affect the availability of suitable habitats.

The Biodiversity Management & Climate Change Adaptation project, which is led by the Alberta Biodiversity Monitoring Institute with collaborators from the University of Alberta and the Miistakis Institute, is developing climate change vulnerability indices for Alberta species (Alberta Biodiversity Monitoring Institute 2013). Canada warbler is considered of "Medial Vulnerability" to climate change; however, at this time it is unclear what implications this information has for the species' provincial status evaluation.

5. Other Limiting Factors – Over-browsing by deer can negatively impact ground-nesting songbirds that depend on dense understory growth. Although white-tailed deer have increased substantially in Alberta, current densities (0.7 – 1.7 white-tailed deer per km^2 in north-central Alberta; Latham et al. 2011) are substantially below those reported in systems where over-browsing has been reported. For example, DeGraaf et al. (1991) report that Canada warblers may avoid stands in Massachusetts where white-tailed deer are abundant ($13/km^2$ – $23/km^2$), but they do not avoid stands where deer are present in low numbers ($1/km^2$ – $3/km^2$). On Haida Gwaii, black-tailed deer densities range as high as $21/km^2$ – $36/km^2$ and bird species that were dependent on understory vegetation were significantly less abundant on islands with high numbers of deer (Allombert et al. 2005). DeCalesta (1994) estimated a threshold deer density of $7.9/km^2$ – $14.9/km^2$ was necessary for numbers of forest songbirds to be negatively impacted by over-browsing. Although concerns regarding the impact of deer on Canada warblers are currently unwarranted in Alberta, management may be necessary in the future if deer numbers continue to increase.

Local avian abundance may respond positively to insect outbreaks through immigration and increased productivity. Some warbler species have a known association with spruce budworm, an irruptive herbivorous moth. Crawford and Jennings (1989) describe a positive association between numbers of Canada warblers and budworm. The area defoliated by spruce budworm in Canada has declined in recent decades, and Sleep et al. (2009) proposed that reduced budworm numbers were responsible, in part, for declining numbers of Canada warbler. This hypothesis has since been refuted by Venier et al. (2012), based on a critical review

of Sleep et al. (2009) and analysis of a larger data set.

STATUS DESIGNATIONS*

1. Alberta –The Canada warbler has not been listed as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. Its general status has been *Sensitive* in Alberta since 1996 (ESRD 2013; previously termed *Yellow B* [Alberta Environmental Protection 1996]). This designation reflects its relative rarity in the province, a decline in numbers throughout their Alberta range since 1966, and their potential vulnerability to habitat loss or deterioration because of various land uses (ESRD 2013). Prior to 1996, their general status rank was *Status Undetermined* because of the lack of information available to determine an accurate assessment (Alberta Forestry, Lands and Wildlife 1991). The Alberta Conservation Information Management System (2012) ranks Canada warbler as *S3S4*, which recognizes them as apparently secure, but uncommon in the province and vulnerable to extirpation from other factors such as loss of old-growth habitats.

2. *Other Areas* – Nationally, the Canada warbler was assessed as *Threatened* by COSEWIC (2008) and was listed on Schedule 1 of the *Species at Risk Act* as a *Threatened* species in 2010. This designation resulted from significant long-term population declines across their Canadian range that show no signs of being reversed, and because 80% of the breeding range occurs in Canada. Reasons for decline are unclear, but loss of primary forest on the wintering grounds in South America is listed as a potential cause (COSEWIC 2008). In response to the COSEWIC assessment, the Canadian Endangered Species Conservation Council (2011) increased their national risk assessment of Canada warbler from *Secure* in 2000 and 2005 to *At Risk* in 2010. NatureServe (2013a) ranks Canada warbler as *Secure* (*N5*) nationally in both Canada and the United States, and as *Secure* (*G5*) globally because of its large population size and large breeding range. The Canada warbler is also designated a species of *Least Concern* globally by the IUCN (2012) Red List of Threatened Species, although a declining population trend is recognized. Partners in Flight (PIF) list Canada warbler as a species of conservation concern on their U.S.-Canada Watch List (UCWL) and a species of Tri-National Concern (TNC) in North America because of significant large declines in population size, moderate threats on the breeding grounds, and high threats on the non-breeding grounds (Panjabi et al. 2012). PIF also considers Canada warbler to be a U. S. - Canada Stewardship (UCS) species because of their high reliance (> 90% of breeding population) on a single avifaunal biome (i.e., Northern Forest: Bird Conservation Regions 4, 6 – 8, 12, 14). The Canada warbler is included on Audubon's *Yellow List* as a species of conservation concern (Butcher et al. 2008).

The addition of Canada warbler to Schedule 1 of the *Species at Risk Act* was followed by increased provincial general status ranks from *Secure* to *Sensitive* in Ontario and Quebec, and from *Undetermined* (Northwest Territories), *Secure* (New Brunswick, Nova Scotia), *Sensitive* (Prince Edward Island), and *May Be At Risk* (Yukon) to *At Risk* in those provinces (Canadian Endangered Species Conservation Council 2011). Their status in British Columbia has remained at *Sensitive* since 2000. Canada warbler was ranked as *Sensitive* in Saskatchewan in 2000, but was changed to *Secure* in 2005. General status ranks in Saskatchewan and Manitoba have remained at *Secure* since 2005 and 2000, respectively (Canadian Endangered Species Conservation Council 2011).

Provincial NatureServe (2013a) designations generally follow those of the Canadian

* See Appendix 2 for definitions of selected status designations.

Endangered Species Conservation Council (2011): *Vulnerable* (*S3S4*) in Alberta and British Columbia (referred to as *Blue* in British Columbia [B.C. Conservation Centre 2013]), *Critically Imperiled* (*S1*) in Yukon (see also Yukon Conservation Data Center 2012), *Secure* (*S5*) in Saskatchewan (see also Saskatchewan Conservation Data Centre 2012), and eastward ranging from *Apparently Secure* (*S4*) in Manitoba and Ontario to *Vulnerable* (*S3*) in Quebec and the Maritimes, and *Critically Imperiled* (*S1*) in Newfoundland and Labrador. Breeding populations in the northeastern United States are designated *Apparently Secure* (*S4*) to *Secure* (*S5*). Breeding populations in Northwest Territories, North Dakota, and Minnesota have not been assessed or are under review (*SNR/SU*; NatureServe 2013a).

RECENT MANAGEMENT AND RESEARCH IN ALBERTA

Canada warblers have appeared in several bird community-level projects related to forest management in Alberta in the past decade (e.g., Schieck et al. 1995, Hobson and Schieck 1999, 2000, Schieck and Hobson 2000, Schieck and Song 2006), and they are considered to be of high conservation concern in forest management planning in the province (Hannon et al. 2004). Most recently, Ball et al. (2013) undertook a habitat assessment of Canada warblers in Alberta. Their goal was to identify habitats that were particularly valuable for this species and to provide land managers and industry with recommendations to ensure suitable habitats were retained during land-use planning. These results were distributed to forest companies across Alberta to enable them to estimate how their harvest plans will affect the supply of Canada warbler habitat in the future, with the goal of minimizing future losses. This habitat suitability model also will be available to the provincial and federal governments for use in identifying areas of the province where suitable habitat could be managed and protected. At present, forest management companies can voluntarily adjust their harvesting practices to incorporate the habitat recommendations for Canada warbler.

Habitat use does not always equate with habitat quality, which requires some estimate of fitness (Van Horne 1983). Lesser Slave Lake Bird Observatory and E. Bayne (University of Alberta) are conducting multi-year research projects on Canada warbler. Lesser Slave Lake Bird Observatory is working to understand patterns of space use, resources within used areas, and variation in individual survival and annual reproductive success, which are important components of fitness and of population dynamics (Flockhart and Krikun 2012). They also are collecting detailed information on insect prey use and availability, predator abundance, and vegetation. Measures of fine-scale habitat associations are important components of habitat suitability that may not be easily detected by coarse-scale assessments. Their goal is to determine how spatial and temporal variability in these habitat components affects space use and, ultimately, breeding success, which will improve our understanding of what constitutes suitable habitat during land-use planning. E. Bayne will address similar questions in areas where forest harvesting has occurred, to understand how residual patches and riparian buffer strips influence similar metrics.

Finally, during the development of conservation efforts aimed at Canada warblers, wildlife managers would be wise to consider the effects of climate change. Two ongoing projects are developing climate change models for Canada warbler in Alberta. The Alberta Biodiversity Monitoring Institute is using NatureServe's Climate Change Vulnerability Index to forecast the potential impacts of climate change on Canada warbler (C. Shank pers. comm.; Young et al. 2011). D. Stralberg and the Boreal Avian Modelling Project (Stralberg and Bayne 2013, Stralberg et al. 2013) are developing climate change models that will predict the distribution of Canada warblers in Alberta and across their range under future climate scenarios.

An important component of this project is the identification of refugia where current and future high quality habitats are predicted to overlap. This relaxes the critical assumption that habitats will track changes in climate and only assumes that local habitats will persist in climates similar to current conditions. These refugia should be considered in future conservation planning.

SYNTHESIS

Modern statistical methods suggest that there are significantly more Canada warblers in Alberta than previously estimated. Breeding Bird Survey data show that numbers of Canada warblers in Alberta have continually declined since the late 1960s. This trend should be interpreted with caution because most BBS survey routes in Alberta are located along major roadways in the southern boreal, and these routes do not cover the majority of the species' range in the province, which has not been adequately surveyed by BBS. Systematic surveys conducted by ABMI cover the entire province and have the potential to provide useful trend information for Canada warbler in the future once a sufficient number of sites have been visited (Huggard 2013). Additional trend monitoring beyond ABMI's efforts is not required; however, targeted surveys aimed at quantifying the amount of potentially suitable-yet-vacant habitat and the use of habitats that are becoming suitable as a result of succession (e.g., in ALPAC's FMA) could prove useful for understanding observed increases at Calling Lake and the potential for Alberta's population to be rescued by local recruits or immigrants.

There is no information on whether the extent of occurrence or area of occupancy have declined in the past or will decline in the near future so long as suitable habitat is retained on the landscape. Canada warblers are strongly associated with stands of old-growth deciduous forest adjacent to incised streams in landscapes dominated by deciduous forest. However, the value of these habitats for survival and reproduction are unknown. Future research is needed to identify habitat components that increase chances of survival and successful reproduction, to ensure these features are maintained in forest management strategies.

The prevalence of old-growth forest in Alberta is expected to decline. Mature forest stands are preferentially targeted in harvest planning, which contributes to a reduction in over-mature and old stands through time. This decline in the amount of suitable habitat for Canada warblers is expected to lead to a decline in population numbers. The quantity and spatial configuration of old-growth stands and retention patches in current harvest planning may be inadequate for ensuring a continued supply of suitable breeding habitat. Research is needed to determine the amount and configuration of old-growth forest required at the landscape scale for Canada warbler populations to be successful. Research is also needed at the local scale to quantify associations with different sized streams to identify suitable riparian buffer widths, and to identify the amount of tree retention, retention patch size, and appropriate cut-block treatments that are necessary for Canada warblers to use harvested areas. Finally, detailed habitat studies that include movement of adults and fledglings are needed to ensure the species is not adversely affected by fragmentation of old-growth habitat.

Population declines observed on the breeding grounds are assumed to be due, in part, to loss and degradation of wintering habitat. However, relationships between winter habitat use and survival have not been thoroughly studied. Research linking Alberta-breeding Canada warblers to their wintering sites would allow the creation of partnerships that promote research and the preservation of important winter habitats (for example, see Southern Wings Program [www.fishwildlife.org]). Support for the protection of Important Bird Areas (IBAs) within the Canada warblers' winter range may also provide sufficient habitat for a significant proportion of their population (Davidson et al. 2011).

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Appendix 1. Data sources summary

Database	Project Name or Observer	Type of Location Data	Type of Data	Types of Additional Information	Number of Observations	Time Span
eBird [Cornell Lab of Ornithology]	eBird	Geographic	incidental		91 (including 119 individuals)	1979 - 2012
WildSpace [Environment Canada]	Environment Canada [C.L. Mahon], Joint Oil Sands Monitoring, Boreal Landbirds	UTM	survey		45 (including 52 individuals)	2011 - 2012
FWMIS [Fisheries and Wildlife Management Information System, AB]					3340 (including 3430 individuals)	1993 - 2012
	AMEC Earth & Environmental, Hammerstone Corp. Lease Surveys	UTM	survey		1	2009
	AMEC Earth & Environmental, Ivanhoe Lease Surveys	UTM	survey		1	2009
	AXYS Environmental Consulting Ltd., Gulf Surmont Project	UTM	survey		3	1998
	AXYS Environmental Consulting Ltd., TrueNorth Energy Fort Hills Oil Sands Project	UTM	unknown		21 (including 22 individuals)	2000 - 2001
	AXYS Environmental Consulting, Ltd., E2 Environmental Alliance: Blackrock-Orion Environmental Impact Assessment	UTM	incidental; survey		5	2001
	AXYS Environmental Consulting, Ltd., Petro-Canada MacKay River Oil Sands Project	UTM	survey		6	1999
	AXYS Environmental Consulting, Ltd., North Central Corridor Pipeline Surveys	UTM	survey		4	1999

Appendix 1 continued:

Database	Project Name or Observer	Type of Location Data	Type of Data	Types of Additional Information	Number of Observations	Time Span
FWMIS continued:	Beaverhill Bird Observatory	Geographic	banding	Age	16	2008
	Birch Mountain Resource Ltd., Wildlife Monitoring	UTM	unknown		1	2007
	Calling Lake Fragmentation Project 1993-2007	UTM	survey		103	2006 - 2007
	D. Collister	Geographic	banding		1	2010
	Ghostpine Environmental Services Ltd., Williams Energy (Canada) Inc. Pipeline Project Surveys	UTM	survey		3 (including 4 individuals)	2008
	Golder Associates Ltd., Breeding Bird Survey for CNRL Kirby	UTM	survey		1	2011
	Golder Associates Ltd., Canadian Natural Resources Limited Horizon Oil Sands Project	UTM	survey		14	2001
	Golder Associates Ltd., Cenovus Narrows Lake Project Phase I, 2008-2010	UTM	survey		1	2008
	Golder Associates Ltd., Confidential Project 2011-72, 2007-2011	UTM	survey		4 (including 5 individuals)	2007 - 2011
	Golder Associates Ltd., Confidential Project 52, 2007-2011	UTM	incidental		3	2011
	Golder Associates Ltd., Shell Jackpine Wildlife Baseline Inventory	UTM	survey		2	2001

Appendix 1 continued:

Database	Project Name or Observer	Type of Location Data	Type of Data	Types of Additional Information	Number of Observations	Time Span
FWMIS continued:	Golder Associates Ltd., Suncor's Environmental Impact Assessment for the Voyageur North Steepbank Project	UTM	survey		2	2004
	Inglewood Bird Sanctuary [D. Collister]	UTM	banding	Age	30	1992-2011
	Owl Moon Environmental Inc.	Geographic	banding	Age	4	2011
	Lesser Slave Lake Bird Observatory	UTM	banding; targeted banding	Age	3074	1993 - 2011
	Nature Conservancy of Canada, Baseline Inventory of Pope, J. Property	Alberta Township System	unknown		1	2012
	Northern Alberta Boreal Research Station, 1993-1999	UTM	unknown		20 (including 107 individuals)	1993 - 1994
	Royal Alberta Museum	Geographic	collection		2	2009
	STRIX Ecological Consulting, Weyerhauser Songbird Monitoring Program, 1998 – 2010 [Grande Prairie and Pembina FMAs]	UTM	survey		40	2000 - 2010
	Teck Frontier Oilsands Mine Project	UTM	survey		14	2008 - 2012
	TERA Environmental Consultants, Access Pipeline Inc. Access Northeast Expansion	UTM	survey		1	2012
	TERA Environmental Consultants, ATCO Pipelines Southern Extension Replacement Project - Phase 3	Alberta township system	unknown		1	2010
	TERA Environmental Consultants, Pipeline Management Inc. Cold Lake Mainline South Loop Pipeline Project	UTM and Alberta Township System	survey		2	2012

Appendix 1 continued:

Database	Project Name or Observer	Type of Location Data	Type of Data	Types of Additional Information	Number of Observations	Time Span
FWMIS continued:	University of Alberta, Ecosystem Management Emulating Natural Disturbance (EMEND) project	UTM	survey		17	2006
	Wildlife Management (reviewed data), Sightings of wildlife in Peace River and Upper Hay Management Areas, 2011-2012	Geographic	unknown		1	2012
	Wildlife Management, Identification of Priority Wildlife Habitat at Calhoun Bay Provincial Recreation Area	Geographic	survey		1	2008
	WorleyParsons, Suncor MacKay River Wildlife Monitoring Program, 2011	UTM	survey		1	2011
BAM [Boreal Avian Modelling Project]	BAM data partners: http://www.borealbirds.ca/index.php/data_partners	Geographic	Survey		953	1993-2012
	J.R. Ball and E.M. Bayne, Habitat association of Canada Warbler in Alberta	Geographic	targeted survey; incidental	Sex, reproductive status	50 (including 56 individuals)	2012
ABMI [Alberta Biodiversity Monitoring Institute]		Geographic	Survey		155	2003-2012
Nature Alberta (Federation of Alberta Naturalists)	First Breeding Bird Atlas of Alberta	Geographic (10 km x 10 km centroid)	Unknown	Breeding status	99	1987-1991
Nature Alberta (Federation of Alberta Naturalists)	Second Breeding Bird Atlas of Alberta	Geographic (10 km x 10 km centroid)	Unknown	Breeding status	191	2000-2005
Other	Matrix Solutions, Inc.	UTM	incidental; survey		14	2007-2010

Appendix 2. Definitions of status ranks and legal designations.

A. General Status of Alberta Wild Species Categories (used in 2000, 2005 and 2010 General Status exercises) (Alberta Environment and Sustainable Resource Development 2011)

Rank	Definitions
At Risk	Any species known to be *At Risk* after formal detailed status assessment and legal designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Any species that is not *At Risk*, *May Be At Risk* or *Sensitive*.
Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	Any species that has not been examined during this exercise.
Exotic/Alien	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	Any species no longer thought to be present in Alberta (Extirpated) or no longer believed to be present anywhere in the world (Extinct).
Accidental/Vagrant	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Species at Risk Formal Status Designations
Species designated as *Endangered* under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation (in bold).

Endangered	**A species facing imminent extirpation or extinction.**
Threatened	**A species likely to become endangered if limiting factors are not reversed.**
Species of Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2011)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Not at Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient	A category that applies when the available information is insufficient to (a) resolve a wildlife species' eligibility for assessment, or (b) permit an assessment of the wildlife species' risk of extinction.

D. United States Endangered Species Act (U.S. Fish & Wildlife Service 2005)

Endangered	Any species that is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Appendix 2 continued:

E. Heritage Status Ranks:

Subnational (S) ranks in Alberta (after Alberta Conservation Information Management System 2013)

S1	Known from five or fewer occurrences or especially vulnerable to extirpation because of other factors.
S2	Known from 20 or fewer occurrences or vulnerable to extirpation because of other factors.
S3	Known from 100 or fewer occurrences, or somewhat vulnerable due to other factors, such as restricted range, relatively small population sizes, or other factors.
S4	Apparently secure. Taxon is uncommon but not rare. Potentially some cause for long-term concern because of declines or other factors.
S5	Secure. Taxon is common, widespread, and abundant.
SX	Taxon is believed to be extirpated from the province. Not located despite intensive searches of historical sites and other appropriate habitat. Virtually no likelihood that it will be rediscovered.
SH	Known from only historical records but still some hope of rediscovery. Evidence that the taxon may no longer be present but not enough to state this with certainty.
S?	Not yet ranked, or rank tentatively assigned.
S#S#	A numeric range rank is used to indicate any range of uncertainty about the status of the taxon. Example: S2S3 or S1S3. Ranges cannot skip more than two ranks.
SU	Taxon is currently unrankable because of a lack of information or substantially conflicting information. Example: native versus non-native status not resolved.
SNR	Not ranked. Conservation status not yet assessed.
SNA	Not applicable. A conservation status rank is not applicable because the species or ecosystem is not a suitable target for conservation activities. Example: introduced species.
S#?	Inexact numeric rank. Applied when a specific rank is most likely appropriate but for which some conflicting information or unresolved questions remain.

Global (G), National (N) and other Subnational (S) ranks (after NatureServe 2013b)

G1/N1/S1	Critically Imperiled. At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2/N2/S2	Imperiled. At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
G3/N3/S3	Vulnerable. At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
G4/N4/S4	Apparently Secure. At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5/N5/S5	Secure. At very low risk or extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.
GX/NX/SX	Presumed Extinct/Extirpated. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood of rediscovery.
GH/NH/SH	Possibly Extinct/Extirpated. Known from only historical occurrences but some hope of rediscovery.
G?/N?/S?	Inexact Numeric Rank. Denotes inexact numeric rank.
G#G#/ N#N#/S#S#	A numeric range rank (e.g., G2G3, G1G3) is used to indicate the range of uncertainty about the exact status of a taxon or ecosystem type. Ranges cannot skip more than two ranks.
GU/NU/SU	Unrankable. Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
GNR/NNR/ SNR	Unranked. Conservation status not yet assessed.
GNA/NNA/ SNA	Not Applicable. A conservation status rank is not applicable because the species is not a suitable target for conservation activities

Appendix 3: Technical Summary

A summary of information contained within this report, and used by the Scientific Subcommittee of Alberta's Endangered Species Conservation Committee for the purpose of status assessment based on International Union for the Conservation of Nature criteria. For definitions of terms used in this technical summary, go to:
http://www.iucnredlist.org/technical-documents/categories-and-criteria, and
http://www.cosepac.gc.ca/eng/sct2/sct2_6_e.cfm

Genus species: *Cardellina canadensis*
Common name: Canada warbler
Range of occurrence in Alberta: Primarily associated with old-growth deciduous forest near incised streams in the Boreal Forest and Foothills natural regions.

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time, as indicated in the most recent IUCN guidelines, is being used) See Conservation Biology (4. Demography and Dispersal), p. 9. Average age of breeding adults and adult survivorship are not known, but based on demographic information (i.e., 4-year-old males being reported as common in Eastern NA; longevity records of approximately 8 years; average return rate for males in New Hampshire of 52%; average clutch size of 4-5 eggs and average young fledged per nest of 3.8) generation length is likely in the range of approximately three years.	Likely 3 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? See Population Size and Trends (1. Alberta), p. 10 and Figure 3, p. 12. Alberta Breeding Bird Survey data shows a decline. The trend based on BBS data should be interpreted with caution because most survey routes in Alberta are located along major roadways in the southern boreal and do not cover the majority of the species' range in the province, which has not been adequately surveyed. Also, long-term data from a study that has monitored songbirds annually since 1993 at Calling Lake, Alberta, show a substantive, local increase in the number of Canada warblers beginning around 2007. The cause of the increase at Calling Lake is not known, nor is it known whether this is an anomaly or if local populations are increasing elsewhere in the province.	Yes – estimated (but see qualification at left)

(Appendix 3 continued)

Estimated percent of continuing decline in total number of mature individuals within 5 years See Population Size and Trends (1. Alberta), p. 9. Based on Alberta Breeding Bird Survey data, using the annual index from the trend over the most recent 10-year period. Decline over the most recent five-year period is expected to have occurred at a similar rate to the trend that has been estimated for the most recent ten years.	21.6% decline estimated over the most recent five years
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. See Population Size and Trends (1.Alberta), p. 9 Based on Alberta Breeding Bird Survey data.	38.5% decline estimated over the most recent 10 years
[Projected or suspected] percent reduction in total number of mature individuals over the next [10 years, or 3 generations]. See Population Size and Trends (1.Alberta), p. 9. Based on Alberta Breeding Bird Survey data. Continued decline at a similar rate is expected over the next ten years, although the rate of population decline might increase somewhat in some areas in the short term.	Approximately 39% decline projected over the next 10 years
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10-year, or 3-generation] period, over a time period including both the past and the future. See Population Size and Trends (1.Alberta), p. 9.	Approximately 39% estimated and projected over any 10 years (including both past and future)
Are the causes of the decline clearly reversible and understood and ceased? See Limiting Factors (first paragraph), p. 13.	No

(Appendix 3 continued)

Are there extreme fluctuations in number of mature individuals? See Population Size and Trends (1.Alberta), p. 10 and Figure 3, p. 12. Breeding Bird Survey data do not indicate extreme fluctuation.	No

Extent and Occupancy Information

Estimated extent of occurrence See Distribution (1. Alberta), p. 1 and Figure 1, p. 2. Based on a minimum convex polygon around observations with evidence of breeding.	376,595 km^2
Area of occupancy (AO) (Always report 2-km x 2-km grid value. An additional estimate of AO using a measure that is more biologically relevant to the species may be included). See Distribution (1. Alberta), p. 1. Based on occupancy of a 2-km x 2-km grid, using known observations with evidence of breeding. This is a minimum estimate as the majority of the area within the area of occupancy has not been surveyed. Using a habitat suitability model, area of occupied habitat in Alberta during the breeding period is estimated as 374,871 km^2. However, the model has not been validated with an independent data set and does not guarantee these habitats are occupied.	1540 km^2 (based on a 2x2 km grid)
Is the total population severely fragmented? See Distribution (1. Alberta), p. 1. The population is continuously distributed across its range; there is no indication of severe fragmentation.	No
Number of locations See Distribution (1. Alberta), p. 1. There is no indication of separate locations.	Unknown

(Appendix 3 continued)

Is there an [observed, inferred, or projected] continuing decline in extent of occurrence? See Distribution (1. Alberta), p. 1 and Limiting Factors (1. Loss and Fragmentation of Breeding Habitat; 4. Climate Change), pp. 13 and 15. Insufficient data to determine. However, agricultural expansion in the southern boreal forest is shrinking the amount of forest habitat; climate change is also expected to shrink the amount of forest in the province.	Unknown, but possible
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? See Distribution (1. Alberta), p. 1 and Limiting Factors (1. Loss and Fragmentation of Breeding Habitat; 4. Climate Change), pp. 13 and 15. Insufficient data to determine. Given the broad distribution of the species, it is expected that if the population is declining, the area of occupancy will respond similarly. However, there will likely be some local increases (such as may be occurring at Calling Lake). The ongoing harvesting of old-growth forest will eventually surpass the gains in habitat area from forest succession and, unless specific management for sufficient old-growth retention occurs, the habitat area available to be occupied by Canada warblers is expected to decline.	Unknown, but possible
Is there an [observed, inferred, or projected] continuing decline in number of subpopulations? See Distribution (1. Alberta), p. 1. Insufficient data to determine, but there is no indication that the population is divided into distinct subpopulations.	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of locations? See Distribution (1. Alberta), p. 1. Insufficient data to determine, but there is no indication that the population is divided into distinct locations.	Unknown

(Appendix 3 continued)

Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? See Limiting Factors, p. 13. Current forest management practices and rates of human development, if continued, will lead to decline in quality and quantity of habitat.	Yes
Are there extreme fluctuations in number of subpopulations? See Distribution (1. Alberta), p. 1. There is no indication that this species' population is separated into distinct subpopulations.	No
Are there extreme fluctuations in number of locations? See Distribution (1. Alberta), p. 1. There is no indication that this species' population is separated into distinct locations.	No
Are there extreme fluctuations in extent of occurrence? See Distribution (1. Alberta), p. 1.	No
Are there extreme fluctuations in index of area of occupancy? See Distribution (1. Alberta), p. 1.	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Total See Population Size and Trends (1. Alberta), p. 10. From various density- and habitat-based models; only adult males estimated in models.	Range of estimates from 202,000 to 2.41 million adult males (would be ~404,000 to 4.82 million mature individuals assuming a male:female ratio of 1:1, which may not be the case)

(Appendix 3 continued)

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. A quantitative analysis was not done for this species	Not applicable

Threats (actual or imminent, to populations or habitats)

- Loss and degradation of breeding habitat
- Climate change
- Loss and degradation of wintering habitats

See Limiting Factors, p. 13.

Rescue Effect (immigration from outside Alberta)

Status of outside population(s)? See Status Designations (2. Other Areas), p. 17. Although Canada warblers are generally declining across their range, numbers in Saskatchewan are increasing and range expansion is occurring in British Columbia.	
Is immigration known or possible? See Population Size and Trends (3. Rescue Potential), p. 13.	Yes.
Would immigrants be adapted to survive in Alberta? See Population Size and Trends (3. Rescue Potential), p. 13.	Yes.
Is there sufficient habitat for immigrants in Alberta? See Population Size and Trends (3. Rescue Potential), p. 13. Declines in the number of Alberta birds are hypothesized to be caused, at least in part, by declines in habitat quality and quantity in Alberta; therefore, immigrants might not find sufficient habitat in Alberta. In areas where short-term gains in habitat are occurring (e.g., Calling Lake), local increases could be a result of immigration (or of local recruitment). Further, without changes to current land-use practices, these gains are expected to be short-lived.	Unlikely

(Appendix 3 continued)

Is rescue from outside populations likely? See Population Size and Trends (3. Rescue Potential), p. 13. Immigrants could reach Alberta and would be adapted to the local habitat, but if current management practices continue, there will not be sufficient habitat to support a significant rescue effect. If land-use practices were to allow an increase in suitable habitat that would support immigrants, then rescue could occur.	Possible, but not likely

Current Status (See Status Designations, p. 17)

Provincial: *Sensitive* (general status)

National: *Threatened*

Elsewhere: BC – *Sensitive*; SK and MB – *Secure*; northeastern U.S. – S4 to S5.

Authors of Technical Summary: Robin Gutsell (ESRD) and Jeff Ball

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